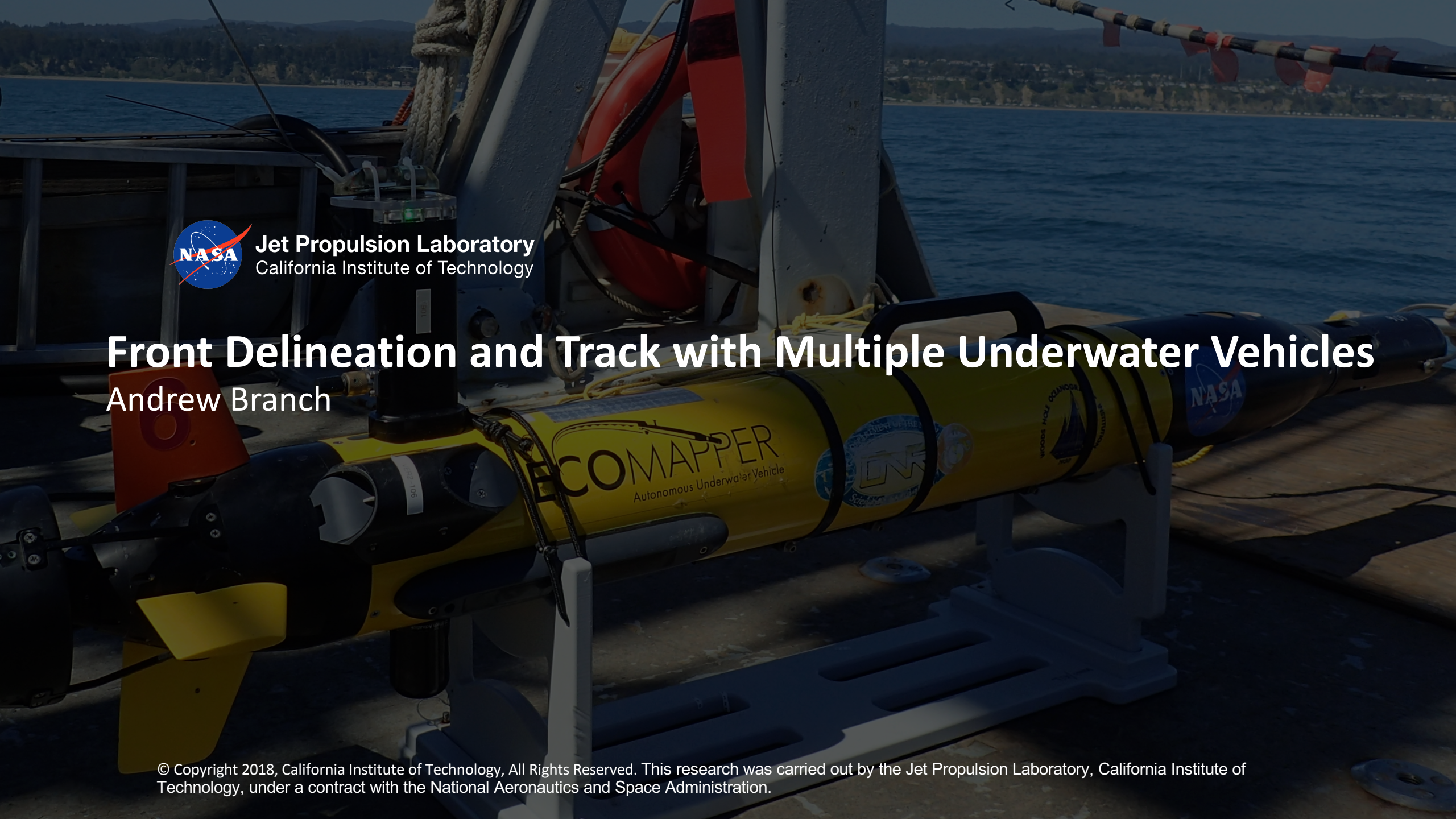


Jet Propulsion Laboratory
California Institute of Technology

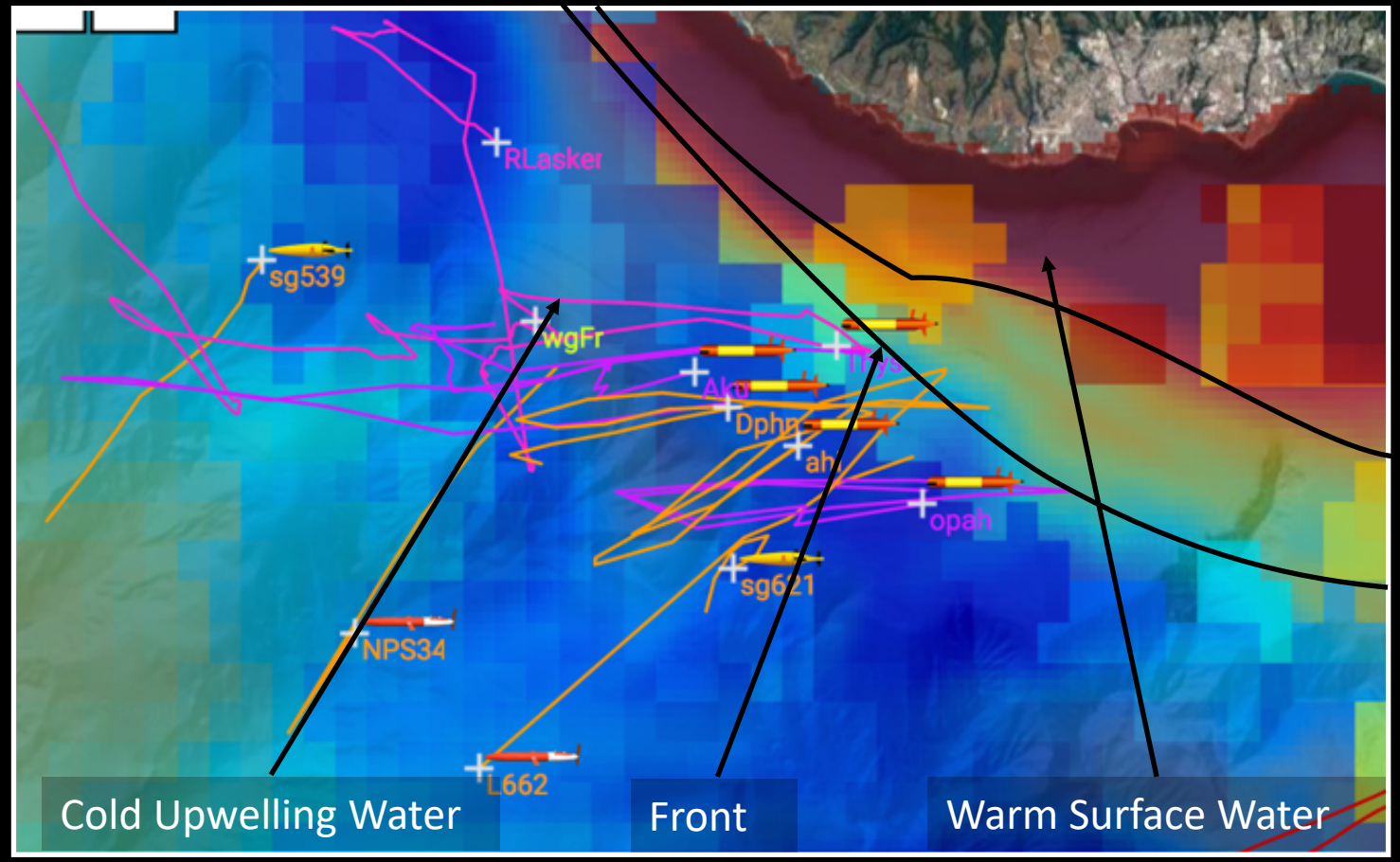
Front Delineation and Track with Multiple Underwater Vehicles

Andrew Branch

 This research was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

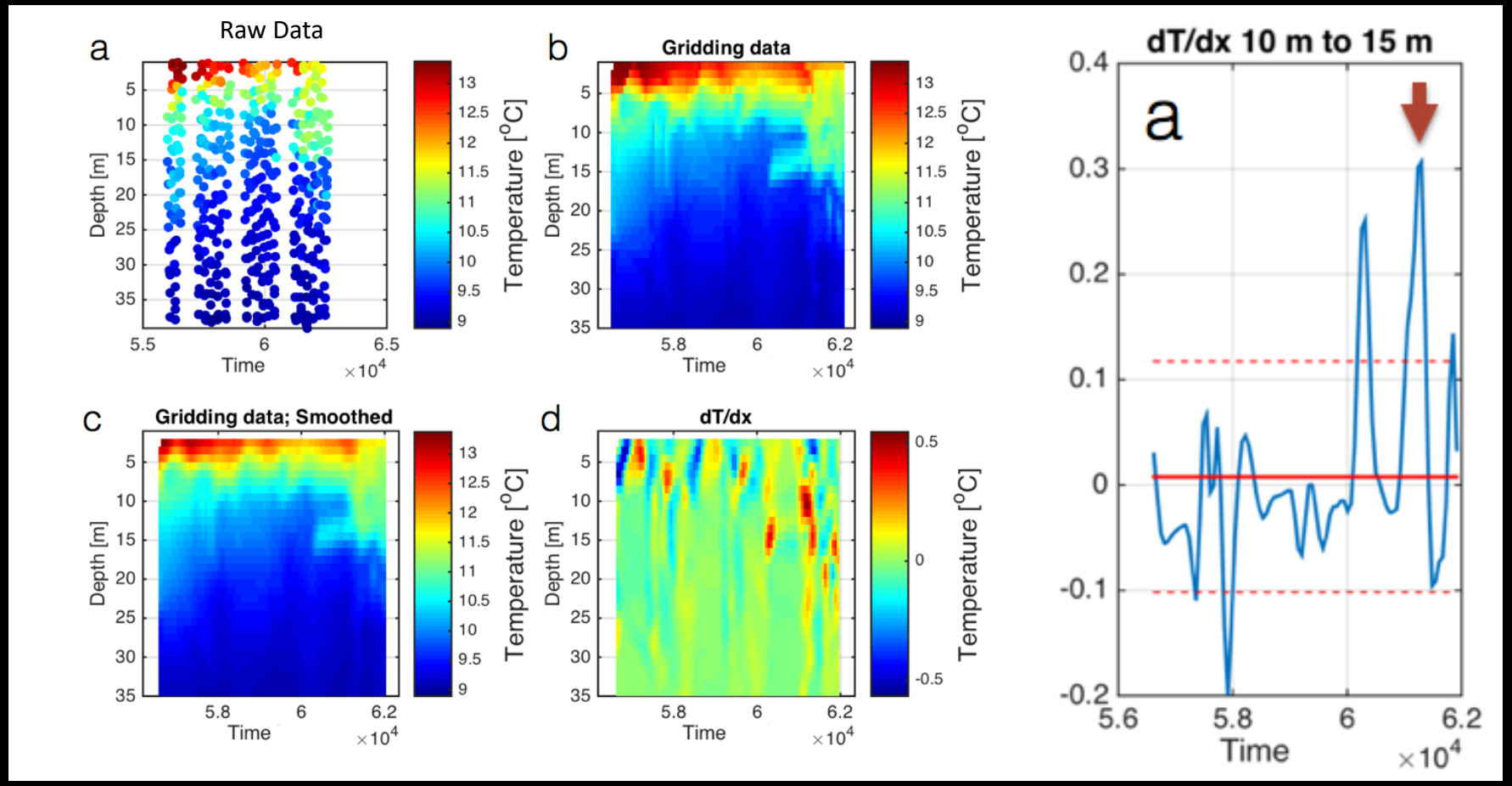
Tracking Ocean Fronts

- Ocean front is the boundary between two distinct bodies of water
- Goal: Repeated transects across an ocean front
- Temperature is shown however any water property can be used



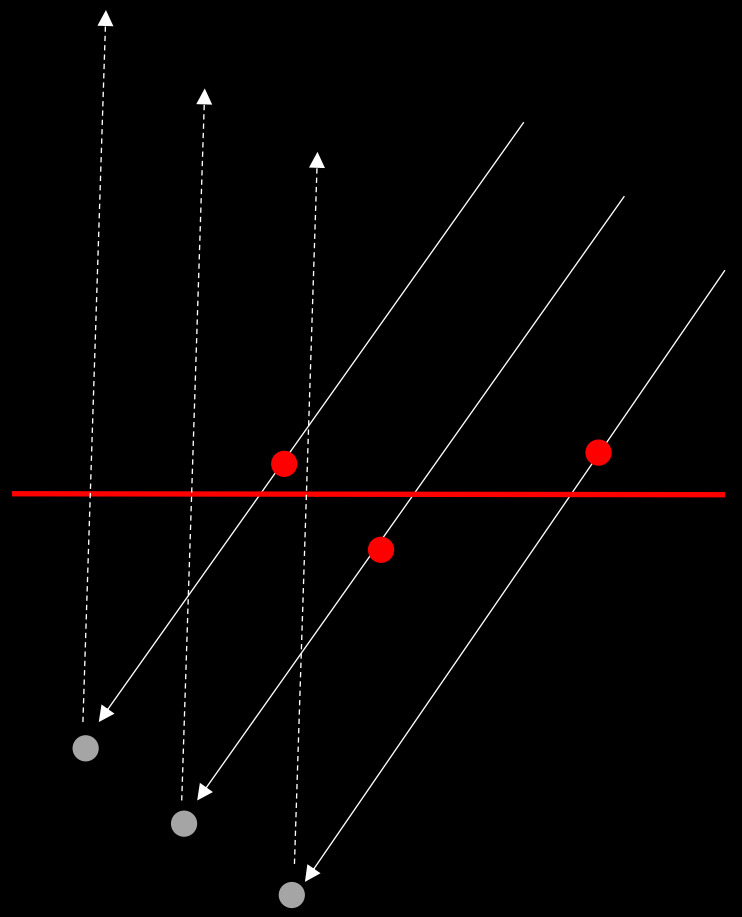
Lateral Gradient Front Detection

- Detect a change in water property over a transect
- Grid, smooth, and differentiate transect data
- Sum data over specified depth
- Declare front when over threshold value
- Select front from declared fronts



Front Delineation and Tracking

- Given multiple vehicles in near parallel transects
- Estimate a linear front from detections
- Command vehicles perpendicular to that front
- Vehicle synchronization is not guaranteed



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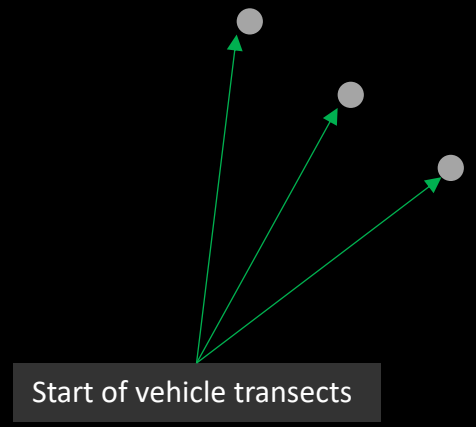

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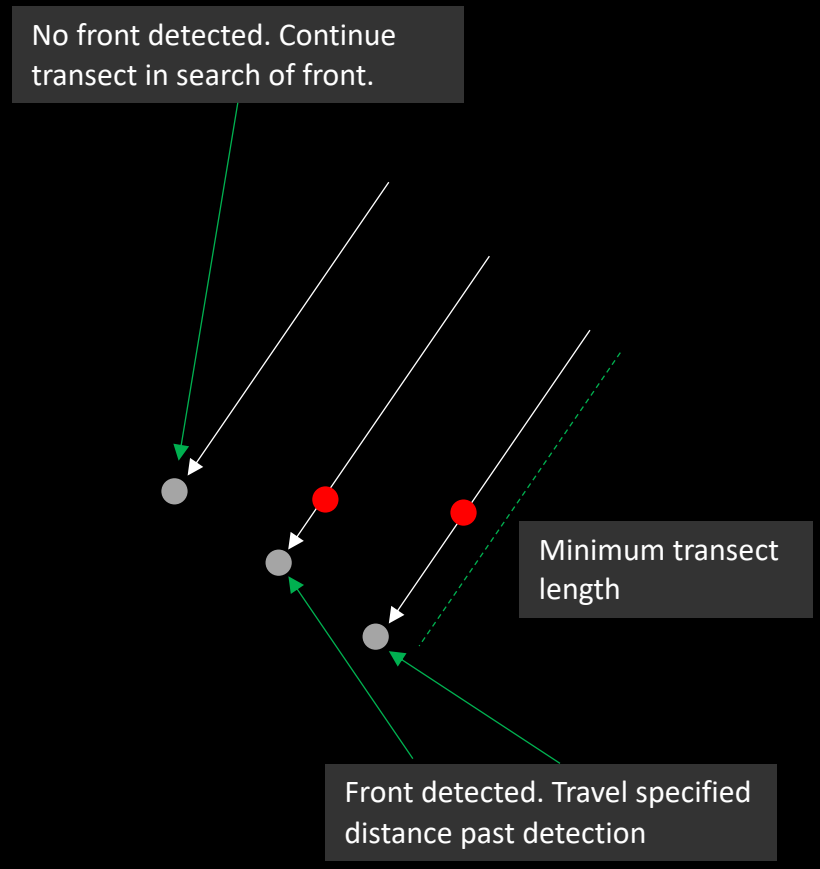

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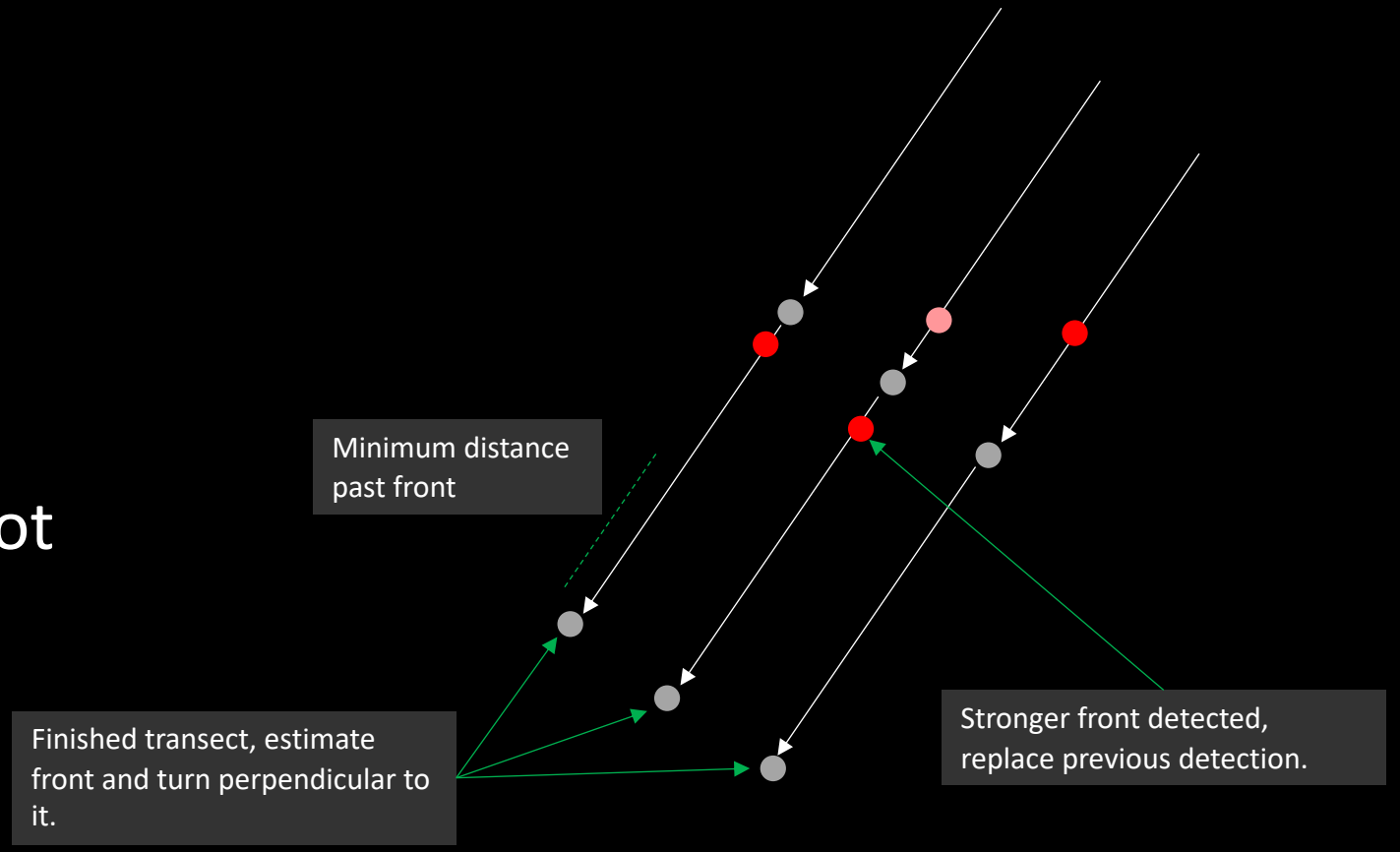

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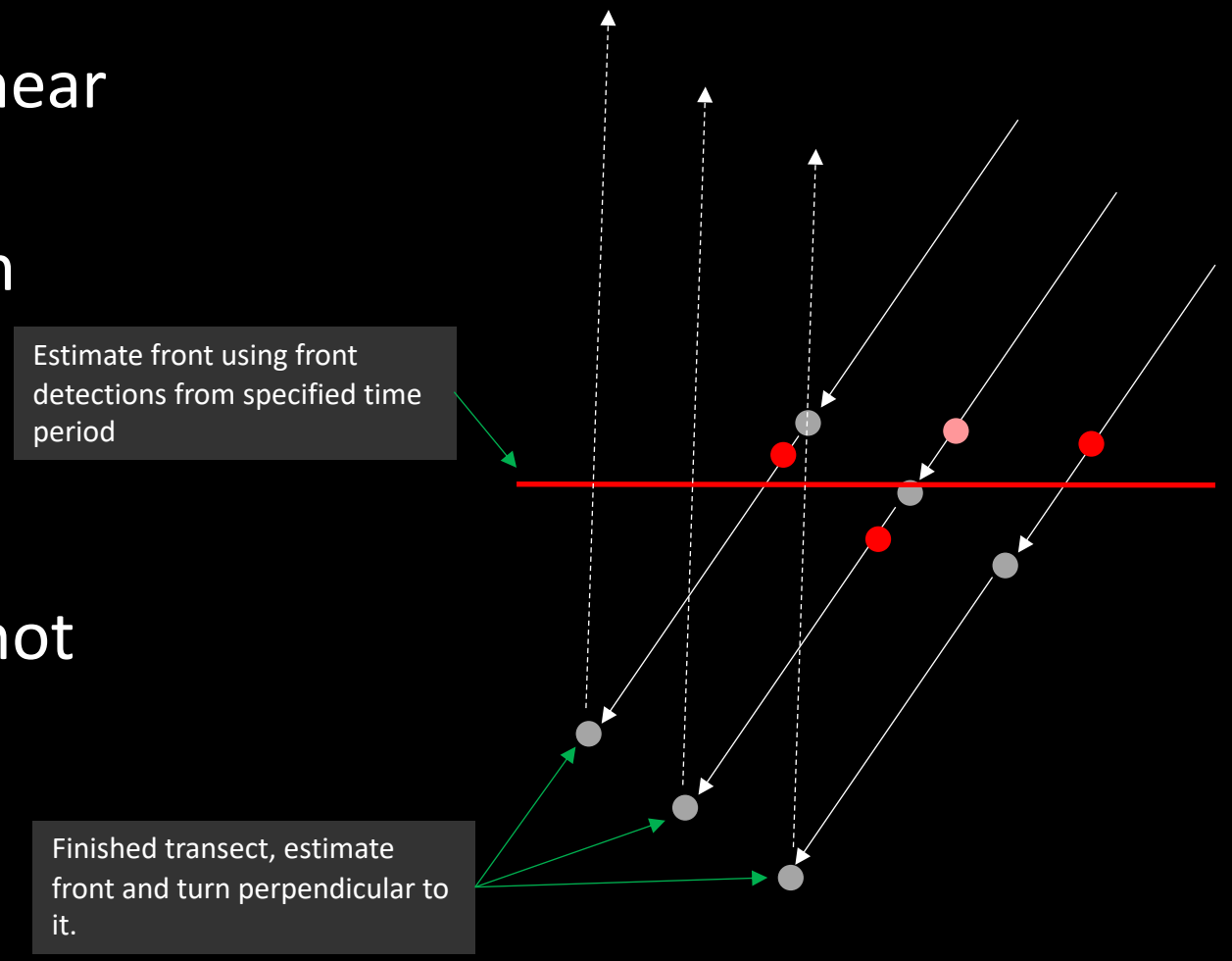


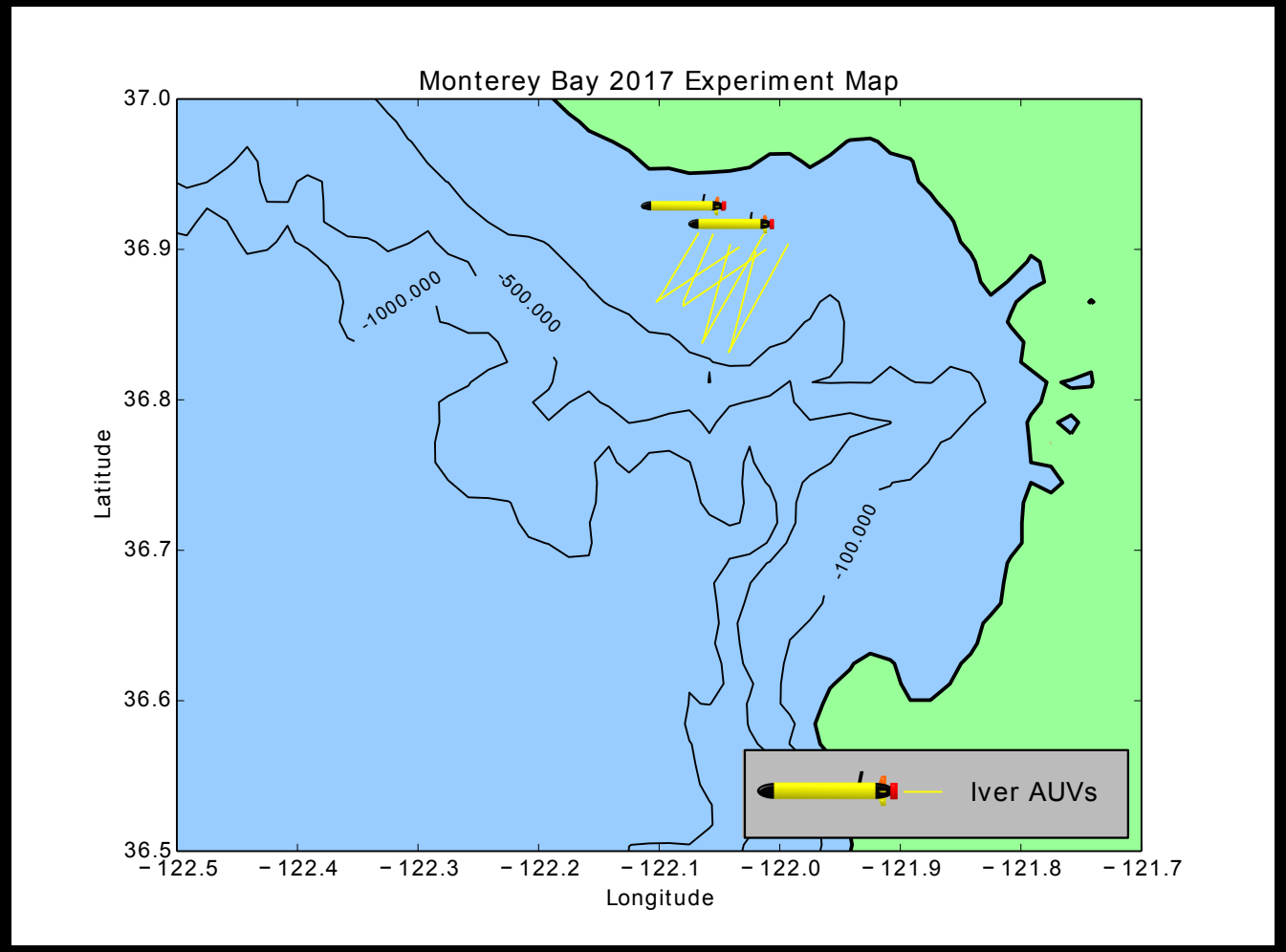
May 2017 Monterey Bay Deployment

Shana Rae

- Front Detection and Estimation
- High level vehicle control

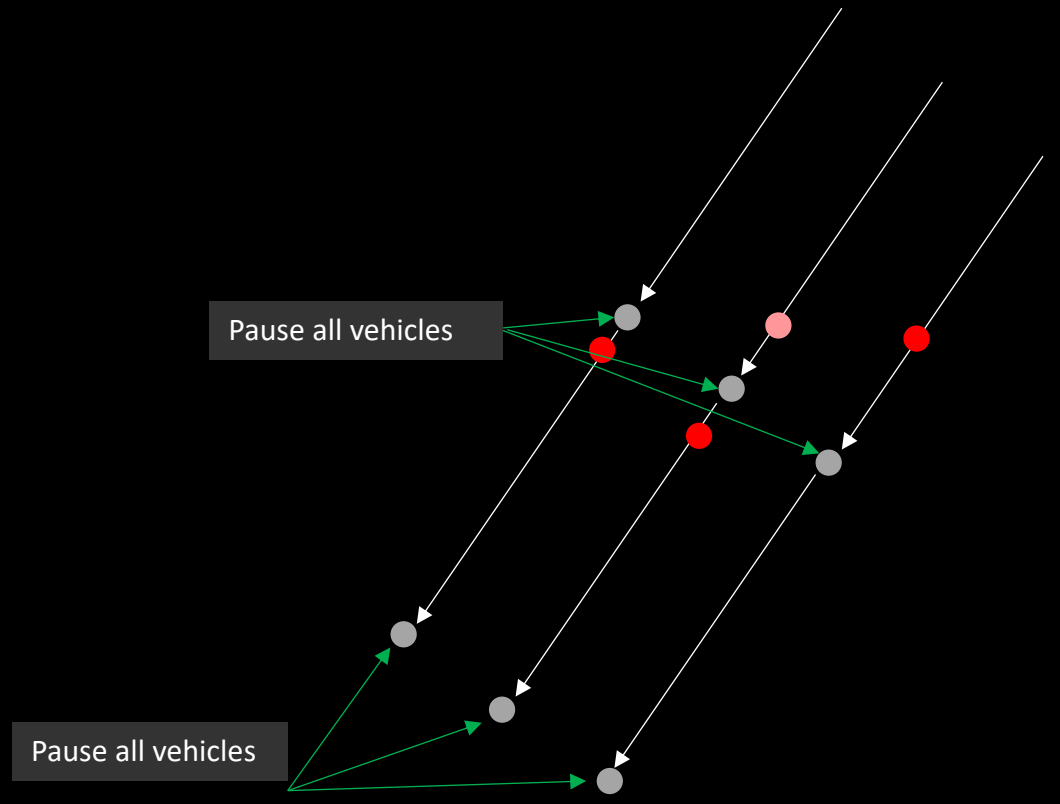
Iver AUV (2)

- 2-4 knots
- ~12 hour endurance



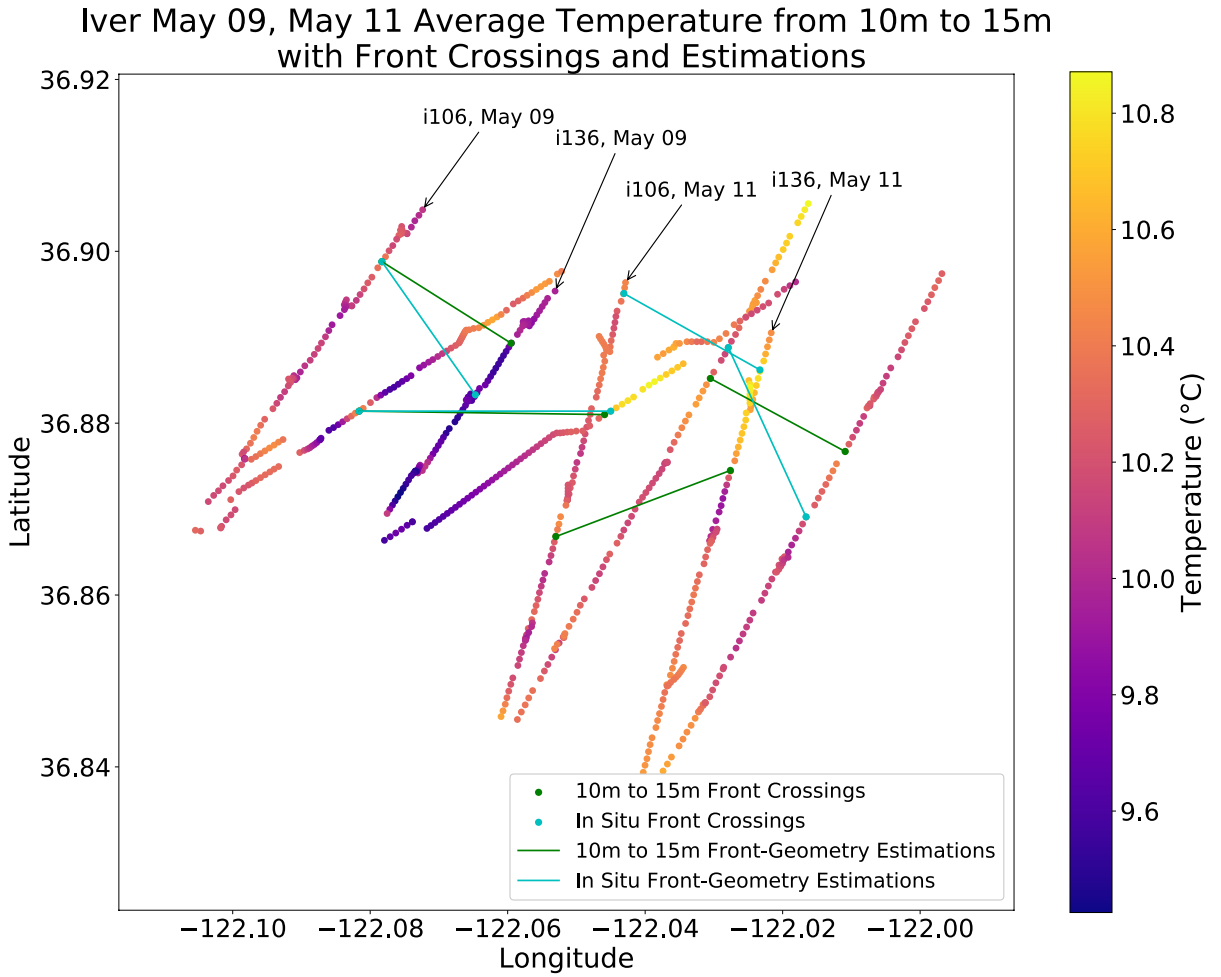
Iver AUV Algorithm Modifications

- Iver AUVs must remain in close proximity for communication and vehicle safety
- Pause at each decision point until all vehicles are present
- Every vehicle either continues transect or turns and starts next transect



Iver AUV Experiment

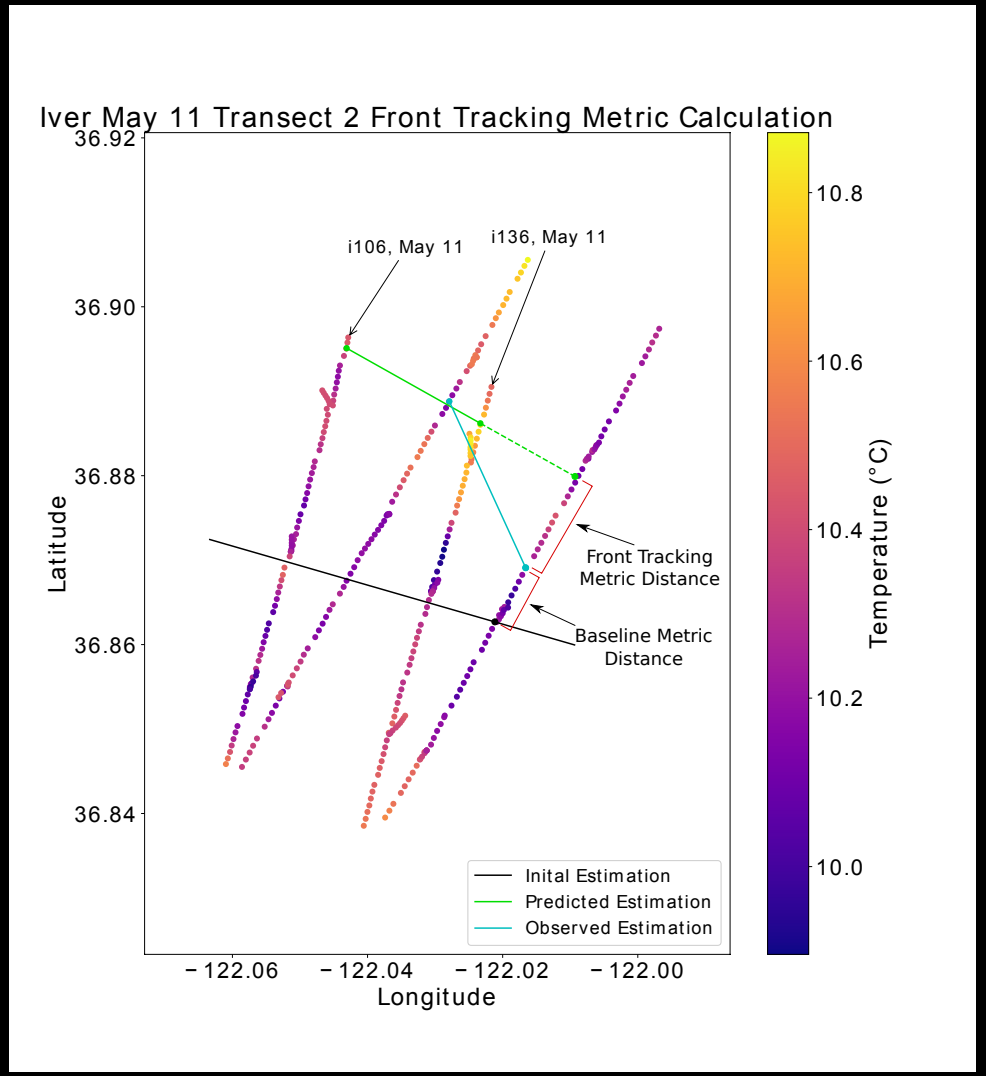
- Minimum transect distance set to 2.5 km past previous estimated front
- If no front was detected in initial transect, continue 2 km
- Vehicles set to turn around immediately after a front is detected



Front Detection Metric

- Compare front estimation accuracy of fixed transects vs front tracking
- Baseline Metric: Distance between initial transect and current front estimation
- Front Tracking Metric: Distance between previous and current front estimation

	Baseline Metric (m)	Front Tracking Metric (m)
Average	1619.598	839.393
Std Dev	943.674	523.301



Conclusion

- Develop method for autonomous tracking of ocean fronts using multiple vehicles
- Demonstrated a proof of concept in Monterey Bay, CA with two Iver AUVS
- Introduced a quantitative metric to evaluate the performance of front tracking algorithms

Future Work

- More deployments and testing
  - Direct comparison between fixed transects and front tracking
- Adding the capabilities to distinguish between fronts
  - Warm-to-Cold vs. Cold-to-Warm
  - Sharp vs. gradual
- Higher fidelity front model
- Develop an on-board version of the algorithm

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